Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat
Science Response 2017/001

Pacific Region

TECHNICAL REVIEW OF ROBERTS BANK TERMINAL 2 ENVIRONMENTAL IMPACT STATEMENT AND MARINE SHIPPING SUPPLEMENTAL REPORT: EFFECTS ON MARINE MAMMALS

Context

Vancouver Fraser Port Authority (VFPA) (the Proponent: previously referred to as Port Metro Vancouver) is proposing to construct and operate the Roberts Bank Terminal 2 Project (the Project), a new three-berth marine container terminal at Roberts Bank in Delta, British Columbia. The Project is proposed to be located next to the existing Deltaport and Westshore Terminals. The new marine terminal is predicted by the Proponent to process up to 260 container ship calls per year at full capacity, with the assistance of two or three large berthing or escort tugs to manoeuver ships into or away from assigned berths. Vessel traffic in the international shipping lanes, outside of the VFPA's jurisdiction to the 12 nautical mile limit of Canada's territorial sea, is anticipated to increase by approximately three ship movements every two days. The Proponent anticipates that construction of the Project could be completed over a five and a half year period. The terminal is designed to operate 24 hours per day year-round.

Roberts Bank, in the Fraser River estuary, consists of complex intertidal and sub-tidal habitats, including intertidal eelgrass beds and productive feeding and rearing habitats for many fish and invertebrate species, as well as providing habitat for marine mammals, including Southern Resident Killer Whales (SRKWs), which are listed as endangered under the Canadian *Species at Risk Act*. The availability of prey has been identified as an important factor influencing the population dynamics of SRKWs, and Chinook and Chum Salmon are identified as representative species in the VFPA's Environmental Impact Statement (EIS).

The Project is subject to an environmental assessment by a Review Panel pursuant to the *Canadian Environmental Assessment Act*, 2012. To characterize the potential environmental effects of the Project, the Proponent prepared the Roberts Bank Terminal 2 Environmental Impact Statement (EIS; Port Metro Vancouver 2015a) which describes construction of project components, operation of the terminal, and the predicted increase in marine traffic within the VFPA's jurisdiction. The Proponent also prepared a Marine Shipping Supplemental Report (MSS; Port Metro Vancouver 2015b) to characterize the predicted environmental effects of marine shipping associated with the Project beyond VFPA's jurisdiction and extending to the 12 nautical mile limit of Canada's territorial sea.

As a federal authority in the environmental assessment for the Project, Fisheries and Oceans Canada (DFO) will be asked to present information to the Review Panel and at public hearings in relation to its expertise on the effects of the Project on fish and fish habitat including marine mammals and aquatic species at risk, and the adequacy of mitigation and offsetting measures and monitoring/follow-up programs proposed by the Proponent.

DFO's Pacific Region Fisheries Protection Program (FPP) has requested DFO Science Branch provide an evaluation of the Proponent's characterization of effects of project construction and

operation, and Project-related increase in marine vessel traffic on marine mammals and marine mammal habitat. The assessment and advice arising from this Canadian Science Advisory Secretariat (CSAS) Science Response (SR) will be used to assist in the development of DFO's submission to the Review Panel during its review of the Roberts Bank Terminal 2 Project.

With respect to the Project's potential effects on marine mammals and marine mammal habitat, this Science Response will address the following objectives:

1. Assess the adequacy of the data, and the technical acceptability of the methods and models used to characterize the potential effects of underwater noise from:
   a. pile driving during project construction;
   b. increased local vessel activity within the Vancouver Fraser Port Authority's jurisdiction; and,
   c. increased vessel traffic outside of the Vancouver Fraser Port Authority's jurisdiction to the 12 nautical mile limit of Canada's territorial sea.
2. Determine if the conclusions related to potential effects of underwater noise are adequately supported by the data, methods and models and identify key information gaps and uncertainty.
3. Determine if the rationale and conclusions related to potential effects of ship strikes are reasonable, and identify key information gaps and uncertainty.
4. In relation to availability of prey for Southern Resident Killer Whale, provide advice regarding the validity of the conclusion that the Project would have a negligible effect on the combined productive potential of juvenile and adult Chinook and Chum Salmon, and identify key information gaps and uncertainty.
5. Provide advice regarding effectiveness of measures proposed by the Proponent to mitigate effects of underwater noise on Southern Resident Killer Whale, identify key information gaps and uncertainty related to these measures, and provide additional recommendations for mitigation, where possible.

This Science Response Report results from the Science Response Process of July 2016 on the Technical Review of Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.

Background

Project Description

The VFPA is proposing to construct and operate the Roberts Bank Terminal 2 Project, next to the existing Deltaport and Westshore Terminals in Delta, British Columbia (Figure 1). In addition to the construction of the new terminal, the Proponent has proposed to widen the north side of the existing Roberts Bank causeway from its east-end connection with the mainland to the entrance of the new terminal. The existing tug basin, connected to the northeast side of the Deltaport Terminal, is also proposed for expansion. The new marine terminal is predicted by the Proponent to process up to 260 container ship calls per year at full capacity, with the assistance of two or three large berthing or escort tugs to manoeuver ships into or away from assigned berths. The terminal is designed to operate 24 hours per day year-round. The main project components have a proposed combined marine footprint area of approximately 179 hectares (ha), listed below by specific component:

- Marine Terminal: 133.5ha, including terminal (116.1ha) and dredged berth pocket and marine approach areas (17.4ha)
- Widened Causeway: 42.4ha
- Expanded Tug basin: 3.1ha

Figure 1. Roberts Bank Terminal 2 Project location and orientation (Fig. 4-1 from Port Metro Vancouver, 2015. Roberts Bank Terminal 2 Project – Environmental Impact Statement, Volume 1 Figures, Section 4).

Analysis and Response

To prepare this response, the following sections of the EIS / additional documents were reviewed:

Document/Section	Title
EIS Section 3[1]	Geographical Setting
EIS Section 4[1]	Project Description
EIS Section 9.8[1]	Underwater Noise
EIS Section 10[1]	Biophysical Setting
EIS Section 13[1]	Marine Fish Effects Assessment
EIS Section 14[1]	Marine Mammals Effects Assessment

[1] Port Metro Vancouver 2015a

Document/Section	Title
EIS Section 16[1]	Ongoing Productivity of Commercial, Recreational, and Aboriginal Fisheries Effects Assessment
EIS Appendix 10-D[2]	Roberts Bank Spatial Ecosystem – Model Sensitivity Analysis
EIS Appendix 14-A[1]	Rationale for Inclusion or Exclusion of Other Certain and Reasonably Foreseeable Projects and Activities in the Cumulative Effects Assessment of Marine Mammals
EIS Appendix 14-B[3]	Southern Resident Killer Whale Noise Exposure and Acoustic Masking Technical Report
EIS Appendix 14-C[4]	Southern Resident Killer Whale Population Consequence of Disturbance Model
Marine Shipping Supplemental Report[5]	Section 8.2 – Marine Mammals Effects Assessment

1. Methods and models used to characterize the potential effects of underwater noise

1.1. Background

Section 14.0 of the EIS provides an assessment of the potential project-related effects and cumulative effects on marine mammals. The spatial, temporal and technical boundaries of the assessment of effects on marine mammals are described in this section. Spatial areas are identified (Local Assessment Area [LAA], Regional Assessment Area [RAA], and Cumulative Effects Assessment Area [equivalent to the RAA]). An addendum to the EIS, the Marine Shipping Supplemental (MSS) report, provides an assessment of the potential effects on marine mammals over larger geographic areas, including an extended region that includes waters beyond the entrance to Juan de Fuca Strait off the west coast of Vancouver Island. The methods used to assess potential effects on marine mammals in the MSS report are generally the same as in the EIS.

Marine mammals were selected as Valued Components (VC), primarily because of their position in the marine ecosystem. Section 14.2 describes marine mammal species found in the general project area (baleen whales, toothed whales, seals and sea lions), their likelihood of occurrence near the Project, their natural history, and the principal means by which the Project may affect them (hearing injury and acoustic disturbance; reduction in prey through habitat loss or reduced quality; increased contaminant uptake; vessel strike). Representative species were chosen for each of the marine mammal subcomponents as follows:

- Toothed whales – represented by Southern Resident Killer Whales (SRKWs)
- Baleen whales – represented by Humpback Whales
- Seals and sea lions – represented by Steller Sea Lions

The RAA for SRKWs includes the Strait of Georgia and adjacent inshore US waters to the entrance to Puget Sound, as well as Juan de Fuca Strait (Figure 2). The RAA for Humpback

[2] ESSA Technologies 2014
[3] SMRU Canada Ltd. 2014a
[4] SMRU Canada Ltd. 2014b
[5] Port Metro Vancouver 2015b

Whales and Steller Sea Lions has mostly the same boundaries but does not include Juan de Fuca Strait west of Victoria (Figure 3).

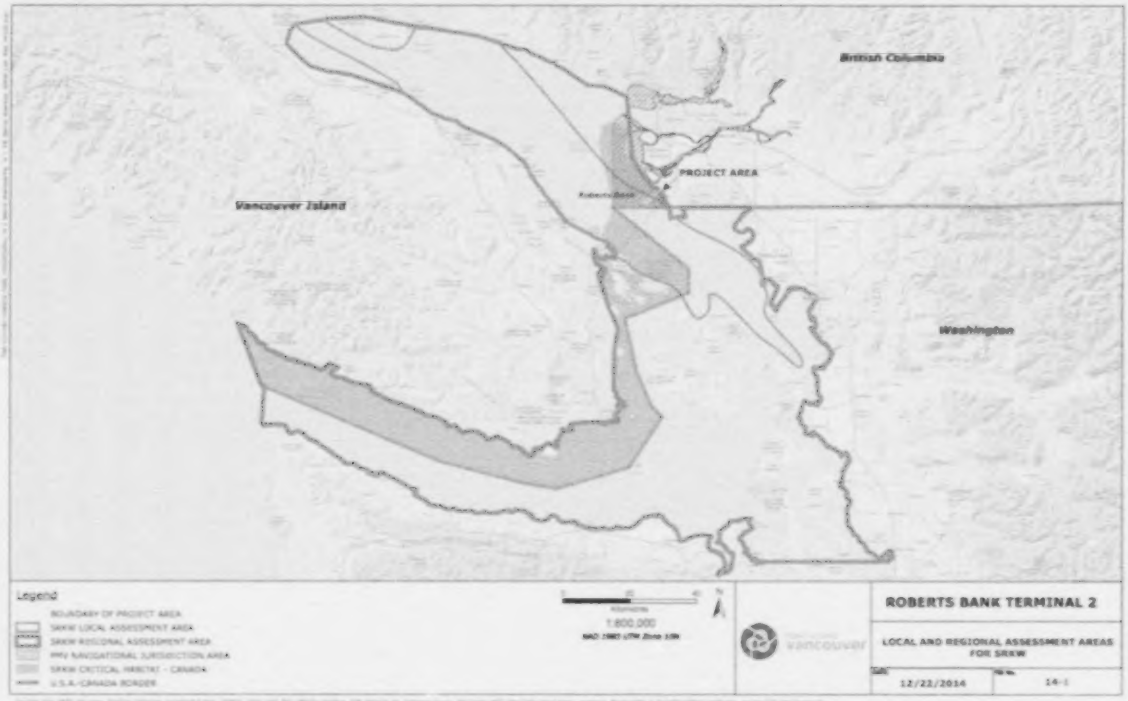

Figure 2. Local Assessment Area (LAA) and Regional Assessment Area (RAA) for SRKWs. (Fig.14-1 from Port Metro Vancouver, 2015. Roberts Bank Terminal 2 Project–Environmental Impact Statement, Volume 3 Figures, Section 14).

The various literature and data sources consulted for information on marine mammals are described in section 14.4 of the EIS. Of particular note is the Southern Resident Killer Whale Technical Advisory Group (SRKW TAG), which the Proponent established during 2012-2013. This group included experts from regulatory agencies (including DFO Science Branch), academia, Aboriginal groups, and key environmental non-governmental organizations that were invited based on their ability to contribute to technical discussions pertaining to SRKWs. The group focused on potential effects on SRKWs from the Project that were identified as requiring the most input to fill known data gaps, including: changes in the acoustic environment, potentially resulting in behavioural disturbance and masking; changes in availability of prey; and, increased risk of exposure to environmental contaminants during Disposal-At-Sea activities. The SRKW TAG recommended a number of field and desktop studies as well as modelling exercises, many of which were implemented and their results are described in the EIS, its Appendices or in other reports on the Proponent's website. These were used in developing the overall assessment of potential effects, mitigation, and residual effects on marine mammals from project activities.

Section 14.5 of the EIS describes the life history, abundance and distribution of SRKWs, as well as life functions and critical habitat of this population in the LAA and RAA. It also describes past and current threats to the population. The section also provides similar material for Humpback Whales and Steller Sea Lions (except for critical habitat, which has been partially identified for these species but falls outside the RAA or LAA for the Project).

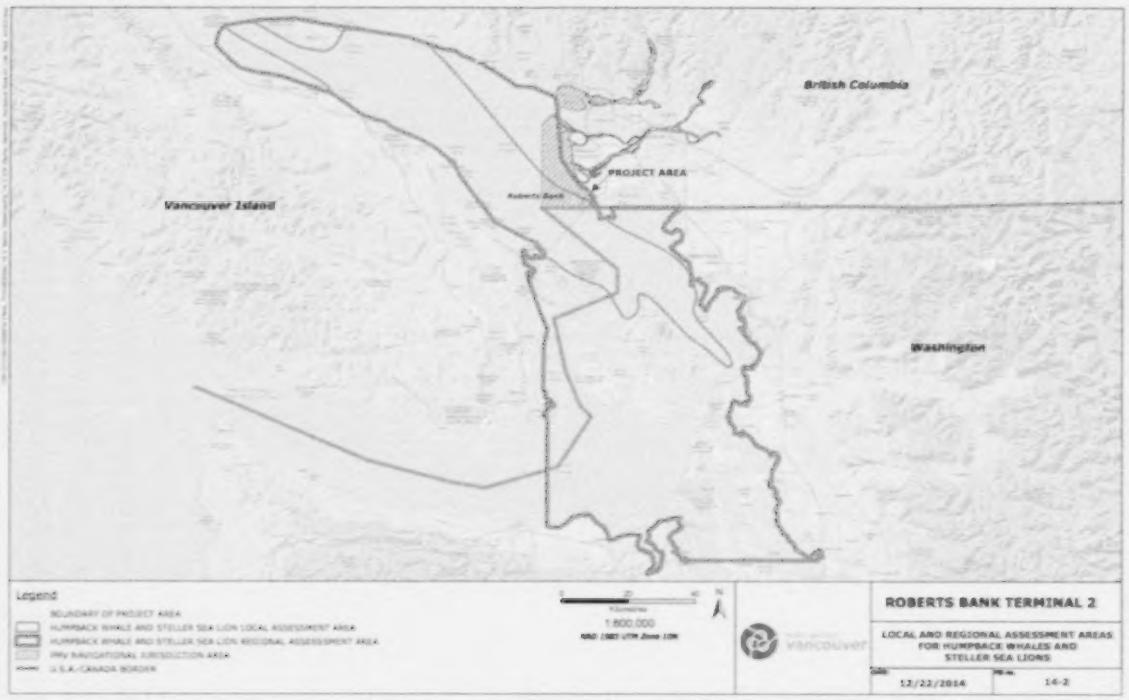

Figure 3. LAA and RAA for Humpback Whale and Steller Sea Lion. (Fig.14-2 from Port Metro Vancouver, 2015. Roberts Bank Terminal 2 Project–Environmental Impact Statement, Volume 3 Figures, Section 14).

Section 14.6 of the EIS describes the potential effects of the construction and operational phases of the Project on these marine mammal species. Most focus in the assessment is on SRKWs and their *Species at Risk Act* (SARA) designated critical habitat. The primary pathway of potential significant effects of the Project is through increased underwater noise which could affect SRKWs by causing: acoustic injury; behavioural effects, including potential displacement or avoidance of a portion of habitat; and, acoustic masking of communication calls or feeding echolocation.

The assessments used estimates of underwater noise that were based on modeling of sound levels and propagation during construction and operation phases of the Project described in Section 9.8 of the EIS. Thresholds for acoustic injury followed established criteria used by the National Oceanic and Atmospheric Administration (NOAA) in the US and recommended by Southall et al. (2007). Noise level thresholds for behavioural disturbance to Humpback Whales and Steller Sea Lions were those used by NOAA (120 dB re 1 µPa). Rather than using this generic threshold for SRKWs, the Proponent followed the SRKW TAG's recommendation to develop SRKW-specific behavioural disturbance thresholds. Three existing field data sets were used: two for documented responses by Northern Resident Killer Whales (NRKWs) to ship traffic and associated noise, and one of hydrophone recordings of vessels and SRKW calls. For all three studies, killer whale behavioural responses were scored based on severity scores described in Southall et al. (2007). Continuous noise level thresholds that could result in low and moderate severity behavioural responses with probabilities of 5%, 50%, and 95% were estimated. These broadband levels range from 117 dB (re 1µPa) for a 5% probability of causing a low severity response to 153 dB for a 95% probability of a severe response. Low-severity behavioural responses were predicted to last 5 min and were considered relatively minor and brief; moderate-severity behavioural responses were predicted to last 25 min with a higher

likelihood of affecting life processes (foraging, reproduction, etc.). From these estimates, the overall spatial and temporal magnitudes of behavioural disturbance responses were estimated. In addition, estimates were also developed for the spatial and temporal extent of potential acoustic masking by ship noise that may reduce the functionality of SRKW echolocation in foraging.

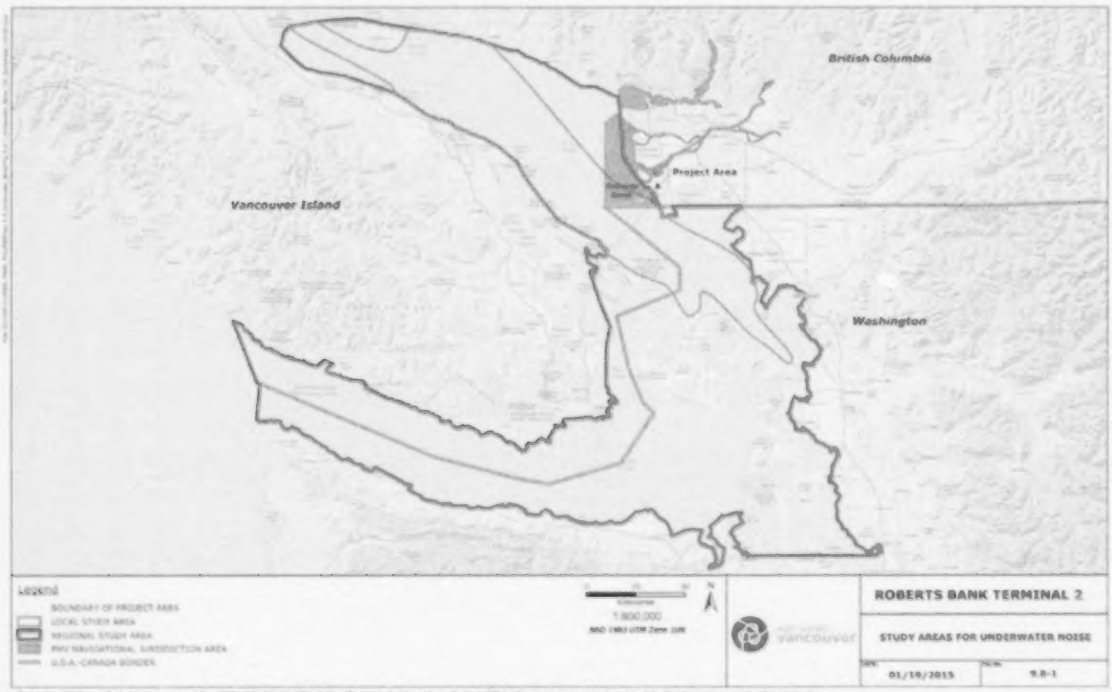

Figure 4. Local Study Area (LSA) and Regional Study Area (RSA) for underwater noise (Fig 9.8-1 from Port Metro Vancouver, 2015. Roberts Bank Terminal 2 Project–Environmental Impact Statement, Volume 2 Figures, Section 9.8).

The cumulative number of low, medium and high severity behavioural disturbance responses and their cumulative durations were modelled for each individual SRKW. Also, the estimated duration of exposure to acoustic masking (aside from behavioural disturbance) was estimated for each individual SRKW (Appendix 14-B). These results were then used in a Population Consequences of Disturbance (PCoD) model, simplified to compensate for data gaps, which is intended to predict the long-term effects of repeated disturbance events on life functions and, ultimately, vital rates of the population (Appendix 14-C). The life function considered of primary importance to SRKWs is prey availability for foraging, as this has been shown to be related to survival and fecundity of this population. The model assumes that cumulative time that individuals experience behavioural disturbance and echolocation masking is equivalent to lost foraging time in the habitat.

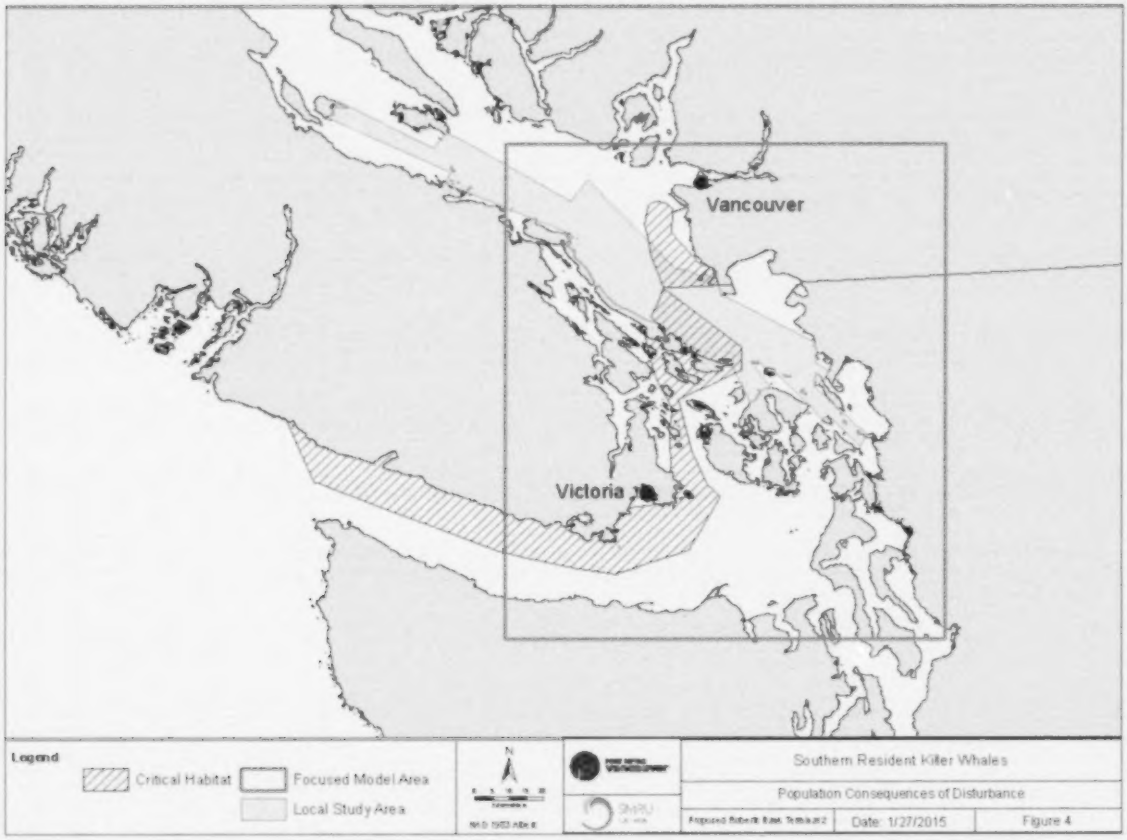

Figure 5. Local Study and Focused Model Areas for the Population Consequences of Disturbance Model (Fig. 4 from Port Metro Vancouver, 2015. Roberts Bank Terminal 2 Project – Environmental Impact Statement, Volume 3, Appendix 14-C).

1.2. Assessment

In general, the data that were used by the Proponent in assessing the potential effects of the proposed project on marine mammals are comprehensive and are the best available. The choice of SRKWs, Humpback Whales and Steller Sea Lions as representative species for the major marine mammal subcomponents – toothed whales, baleen whales, and seals/sea lions – is reasonable. The boundaries for the various spatial assessment areas considered in the EIS and the MSS report are well reasoned and adequate.

A state-of-the-art numerical model developed and run by JASCO Applied Sciences (Canada) Ltd. was used to characterize the potential effects of underwater noise by pile driving and shipping on the ecosystem. The model used available bathymetry information and sea-floor characteristics from available literature and from geoacoustic inversions calculated from transmission loss measurements. The sound speed profile used in the modeling was obtained near Roberts Bank in February 2007. This profile is more upward refractive than available summer profiles—leading to more noise in the upper water column—and ultimately, generating more conservative threshold distances. The modelling also included measured wind-generated ambient noise levels for comparisons and masking analysis. Finally, the model outputs were validated by actual observations of sound transmission data and noise characteristics from

different ship types to assess model fidelity. Available automatic identification system (AIS) data were used for ship-noise modeling. However, as pointed out by the Proponent, this dataset does not include smaller vessels operating in the areas of interest.

Many of the analyses and models to estimate impacts of underwater noise on SRKWs were suggested by independent specialists in the SRKW TAG. Of particular note is the development by the Proponent of killer whale-specific thresholds for behavioural disturbance due to exposure to underwater noise, rather than using generic and somewhat obsolete threshold used by NOAA in the US. This resulted in estimates of severity for behavioural responses based on empirical data collected for resident killer whales in British Columbia and Washington State. Dose-response curves were developed for resident killer whales using data from three field studies: a shore-based theodolite study of NRKWs; a digital acoustic datalogger study (D-Tag) of NRKWs; and, a passive acoustic study in the summer core SRKW habitat. This approach is superior to application of the generic 120 dB re 1µPa received level threshold used in past impact assessments. The severity of killer whale behaviour responses are based on the Southall et al. (2007) severity scores that were developed by international marine mammal experts and are the best available. Acoustic masking of echolocation was estimated by a model presented in Appendix 14-B. This model appears well-developed, using the best information available as inputs, and its output seems reasonable. It must be recognized though that very little is known about the actual importance of echolocation in SRKW foraging behaviour (i.e. little is known about how echolocation affects prey detection and capture, the effective range of echolocation, or the vulnerability of echolocation to noise masking, etc.). Subsequently, little is known about how noise masking may truly affect foraging efficiency.

The PCoD model framework was developed by a National Research Council (NRC) Committee (NRC 2005) in an attempt to estimate how measurable short-term responses result in biologically meaningful changes in populations. The model attempts to estimate the extent to which disturbance causes behavioural and physiological changes, and then, in turn, how these changes affect an individual's health and subsequently vital rates (survival and fecundity). These estimated changes in vital rates are then used to model consequences at the population level. In the case of this application to SRKWs, the full PCoD model could not be parameterized because of a lack of understanding of how disturbance affects the physiology and subsequently the health of SRKWs (e.g., the link between prey intake and body condition, the link between body condition and survival or reproductive potential). As a result, these linkages conventionally used in PCoD models were removed and instead, a simplified version of the model was used that attempts to make a direct link between behavioural disturbance and vital rates as mediated by time available for foraging. This approach is based on an unpublished program (the CONCEAL project, see Appendix 14-C) with additional modifications that resulted in a "PCoD-Lite" model. This custom model was developed by individuals who have considerable expertise with the PCoD framework and it can be assumed that the model is the best available for this purpose. However, as described under Objective 2 below, it must be recognized that this modeling exercise involves numerous compounding assumptions and limitations such that any results have a high level of uncertainty and low confidence, and must be interpreted cautiously.

2. Results and conclusions related to potential effects of underwater noise, key information gaps and uncertainty

2.1 Background

Section 14.6.2 of the EIS assesses the Project's effects on individual SRKWs and the population's designated critical habitat. During the construction phase, low severity responses are predicted to last 5 minutes and are considered relatively minor and brief. These may occur at ranges of 0.03 km to 22.2 km from construction activities. Moderate severity responses are

predicted to last for 25 minutes and have a higher likelihood of affecting life processes and ultimately vital rates. Ranges from construction activities that could have such sound levels are 0.02 km to 5.42 km. In addition, the estimated radii from construction sources of loud impulsive noise at which hearing injury to SRKWs might occur, based on various predicted thresholds, are described. The only sound source that is considered to be loud enough to potentially cause hearing injury to SRKWs is impact pile-driving, and the maximum estimated radius from this source that could result in such injury is 220 m without mitigation.

The probabilities of behavioural responses to noise from ships approaching, berthing, unberthing and departing from the terminal during the operation phase of the Project are also estimated. It is concluded that the average underwater noise from the Project exceeding average underwater noise levels during existing conditions would be realised approximately 3% of the year, and the remaining 97% of the time underwater noise from the Project is expected to be within existing underwater noise levels. The Proponent suggests that this estimate is considered to be conservative for various reasons and the resultant incremental disturbance effects are judged to be small.

Section 14.6.2.1 concludes that, in the LAA, "the predicted change to the acoustic environment and predicted behavioural responses and acoustic masking, are not predicted to affect an individual SRKW's ability to forage in critical habitat when needed, and is therefore not predicted to result in population-level effects on SRKWs".

The potential for acoustic injury and behavioural disturbance due to project-related noise to Humpback Whales was also assessed in section 14.6. The noise level thresholds for behavioural disturbance and injury used by NOAA and described in Southall et al. (2007) were applied in this assessment. Because only a minor incremental increase in underwater noise levels above existing conditions is anticipated, and because Humpback Whales are considered rare in the humpback LAA and RAA (Figure 14.2 in the EIS), the Proponent concludes that no population-level effects are anticipated. Similar conclusions are made for acoustic injury and behavioural disturbance to Steller Sea Lions.

Section 14.8 characterizes the changes to the ambient acoustic environment that the Proponent claims cannot be fully mitigated (note that noise mitigation measures are proposed for the construction phase, but not the operational phase; see Objective 5 below). Qualitative ratings are provided for the residual effects' magnitude (low, moderate, high), extent (site-specific, local, regional), duration (short-, medium-, or long-term, or permanent), reversibility (fully, partially, irreversible), and frequency (infrequent, frequent, continuous). In terms of operational noise, the Proponent estimates that by the year 2030, there will be 260 container ship calls per year to the project terminal in addition to other shipping in the Roberts Bank area. Models and studies described in Appendix 14-B (Southern Resident Killer Whale Noise Exposure and Acoustic Masking Technical Report) predict that behavioural disturbance responses in the PMV jurisdiction area would occur approximately 3% of the year, when annual average underwater noise from operation is predicted to exceed average existing conditions. These are considered to be of low- and moderate-severity with durations of only 5 or 25 minutes, respectively, until an affected animal's behaviour returns to that prior to disturbance. Overall, they conclude that "predicted behavioural responses and acoustic masking are not predicted to harm an individual or adversely affect the life functions of individual animals, including foraging, mating, resting, or socialising. The difference between existing conditions and conditions with the Project are unlikely to result in effects to individuals that could adversely affect their ability to survive or reproduce."

The Proponent considers Humpback Whales to be potentially exposed to noise levels that could cause disturbance, but considers these to be of short duration and reversible and, given that

Humpback Whales are currently uncommon in the RAA and LAA area for this species, residual effects are unlikely. Similar conclusions are reached for Steller sea lion.

The context of residual effects for each of these species, in terms of resiliency and sensitivity, is described. For SRKWs, it is stated that despite studies and models showing high existing levels of underwater noise and frequency of behavioural disturbance responses and acoustic masking, the Proponent's PCoD model suggests that these are having no effect on survival or reproductive rates. However, they concede that there is considerable uncertainty around these predictions such that it is possible "that current levels of underwater noise from commercial vessel traffic is reducing the ability of SRKWs to successfully forage on Chinook salmon and that this reduction of foraging is limiting population recovery". Given that recreational and small commercial vessels (e.g. whale watching vessels) are not included in the models, the true effects of existing underwater noise may be under-estimated.

Section 14.9 describes the significance of residual adverse effects of the Project on marine mammals. The Proponent defines "significance of a residual adverse effect on SRKWs" as one that either affects one or more individuals or results in a change to critical habitat such that a feature would not be available when needed for an SRKW life function, and to an extent that could jeopardize survival or recovery of the species. This section concludes that "residual adverse acoustic disturbance to SRKWs from the Project is expected to be not significant. Confidence in this determination is considered moderate. This rating is based on the extensive site- and SRKW-specific studies (e.g., SRKW-specific behavioural effect thresholds), modelling, and conservative assumptions incorporated into this assessment." It is also concluded that all three of the critical habitat features (acoustic environment, the availability of prey, and water and sediment quality) for SRKWs will not be affected by the Project, and as such critical habitat destruction will not take place and the survival and recovery of SRKWs will not be limited by the Project.

Any residual effects on Humpback Whales and Steller Sea Lions are concluded to be short-term and reversible with no long-term population consequences. Confidence in these conclusions is considered by the Proponent to be high.

Section 14.10 describes the assessment of potential total cumulative effects on marine mammals resulting from the Project combined with past and present projects and activities as well as that of "other expected, certain and reasonably foreseeable future projects and activities".

Modelling in Appendix 14-B resulted in estimates of the number of low- and moderate-severity behavioural disturbance responses and cumulative durations of affected behaviour for each individual SRKW per year within both the LAA and RAA due to existing and projected shipping levels not including small vessel traffic. Assuming the Project proceeds, the estimated median of low- and moderate-level responses under existing conditions will increase to 1587 (+7%) and 657 (+5%), respectively.

Estimates of the cumulative total hours of echolocation masking and percent of the year with masking for each individual SRKW in both the LAA and RAA are also provided. This analysis estimated a total cumulative increase of 4.63 hours of echolocation masking per whale in the LAA between existing levels and projected future levels. Of this increase, only 8% would be attributable to the Project and the remainder to other activities.

The PCoD model described in Appendix 14-C predicted that no change in survival or reproductive rates of individual SRKW between existing conditions and cumulative future projected conditions. No change is therefore predicted to the relative growth rate or size of the population. A similar conclusion of no predicted effect resulted from the PCoD model regarding

cumulative impacts on SRKW critical habitat ("Modelling of PCoD determined that there was no statistically significant difference in survival, fecundity (reproduction rate), or population growth of SRKWs between existing and future conditions with the Project and future certain and reasonably foreseeable projects and activities").

For Humpback Whales and Steller Sea Lions, it is concluded that cumulative effects could occur in the RAA for these species as a result of the proposed project and other future projects and activities, but the nature and extent of this potential effect is not described.

Section 14.11 summarizes the predicted residual effects and residual cumulative environmental effects of the Project. In summary, the Proponent concludes that "the contribution of acoustic disturbance from the Project in combination with certain and reasonably foreseeable projects and activities is considered unlikely to affect individual SRKWs such that the survival or recovery of the species is jeopardised". The Proponent also concludes that "all three of the critical habitat features (acoustic environment, availability of prey, and water and sediment quality) will not be affected by the Project contribution to cumulative effects, when needed by individuals for their life functions of foraging, mating, resting, or socializing", and that the Project's contribution to cumulative effects will not limit the survival or recovery of the SRKW population. These conclusions are made with a "high" level of confidence. For Humpback Whales, Steller Sea Lions and toothed whales other than SRKWs, it is concluded with a "high" level of confidence that any cumulative effects will be not significant.

The Marine Shipping Supplemental Report provides an assessment of potential effects of the operational phase of the Project over a larger geographic area that includes waters out to 12 nautical miles beyond the entrance to Juan de Fuca Strait. Section 8.2 describes the assessment area, indicators of effects on marine mammals, information sources for the assessment, existing conditions and species occurrence in the area. The natural history, current and historical status and anthropogenic threats to species of conservation concern are described. This section also includes a discussion of the reduced availability of prey for marine mammals due to underwater noise generated by increased shipping associated with the Project. The Proponent predicts that there will be only a minor incremental increase in ambient noise (5%–6.5%) over existing conditions, and that there would be no effect on prey availability as a result.

In the MSS report subsection 8.2.6.2, the predicted behavioural and acoustic masking effects due to underwater noise from marine shipping associated with the Project are described. Thresholds used to estimate noise levels at which behavioural disturbance can be anticipated are the same as in the EIS. The pathways for potential effects to SRKWs and their critical habitat resulting from increased shipping are behavioural effects, including potential displacement or avoidance of a portion of habitat, and acoustic masking of communication calls or feeding echolocation.

Underwater noise levels and zones of potential behavioural disturbance to SRKWs were predicted at four representative locations along the international outbound shipping lanes in the LAA for container ship transit associated with the Project. Using the same approaches, models and response criteria as in the EIS, moderate-severity behavioural responses were predicted to occur from 0.04 km (95% of population) to 2.1 km (5% of population) from a transiting container ship. Information on SRKW occurrence in an 'Extended Region' (or ER, which is western Juan de Fuca Strait to Swiftsure Bank off the mouth of the Strait, Fig. 8.2-5) was incorporated into predictions of the frequency and severity of behavioural disturbance responses, including satellite tag data, detections from passive acoustic monitoring, and sightings. It was estimated that SRKWs are to be present in the ER between 45 and 60 days per year depending on pod.

In the entire LAA, including the Extended Region and Focused Model Area (see MSS report Fig. 8.2-1), it is estimated that the potential lost foraging time during existing conditions is 540.17 hours (22.5 days) per year per individual due to behavioural disturbance and acoustical masking. With the addition of shipping associated with the Project, an additional 20.1 hours (0.84 days) of foraging time is predicted to be potentially lost. Under existing conditions, it is estimated that there are a median of 2262 low- and 844 moderate-severity disturbance responses per individual whale per year, respectively, in the entire LAA. With the additional shipping associated with the Project, this estimate increases to 2348 and 875 responses, respectively. Increases of similar magnitudes are predicted in the median predicted hours and days of disturbance per whale per year.

The Proponent chose not to re-run the PCoD model described in the EIS for the larger Extended Region in the MSS report. The Proponent notes that sensitivity analyses of the PCoD results suggest that substantial changes in the effects of disturbance and masking did not alter the conclusion that the effects of acoustic disturbance on population growth rate are likely to be very small compared to existing conditions.

Similar assessments of the potential effects of acoustic disturbance on Humpback Whales and Steller Sea Lions in the marine mammals LAA (MSS report Fig. 8.2-1) were undertaken. Because the humpback whale population in BC is increasing despite existing levels of vessel traffic and noise, and since only a small increase over existing noise conditions is predicted for the Project, any effects are predicted to be minimal. Similar conclusions are reached for Steller Sea Lion.

Section 8.2.8 of the MSS report provides an assessment of the potential residual effects on marine mammals and their significance. Generally, this section uses methodology and criteria presented in the EIS. For SRKWs, it is concluded that the Project will result in a measurable change including low- and moderate-severity behavioural responses and acoustic masking from continuous noise. However, these changes are judged unlikely to affect SRKW life functions, critical habitat features, population viability, or recovery. Residual adverse acoustic disturbance to SRKWs from marine shipping associated with the Project is expected to be not significant, with a moderate level of confidence. Similarly, for Humpback Whales, the residual effects are considered not significant, with a moderate level of confidence. For Steller Sea Lion, the conclusion is that residual effects will be not significant, with a high level of confidence. Residual effects from ship strikes are considered not significant for SRKWs and Humpback Whales (moderate confidence) as well as Steller Sea Lions (high confidence).

Section 8.2.9 of the MSS report provides an assessment of cumulative residual effects over the entire LAA. It is concluded that cumulative residual effects on marine mammals other than SRKWs are expected to be not significant. For SRKWs, it is concluded that past and existing conditions in the LAA have likely had and are having a significant adverse effect, and future increases in vessel traffic including that associated with the Project are likely to result in a significant cumulative effect.

2.2 Assessment

The estimates described in section 14.6.2 regarding the probabilities of various levels of severity in behaviour responses to broadband noise levels are based on documented behavioural responses from field studies of resident killer whales, which is a superior approach than using generic and obsolete thresholds as has been done in the past. However, it should be recognized that uncertainty exists in these dose-response estimates for behavioural responses and the anticipated duration of these responses before recovery to pre-disturbance behavioural states.

Predictions of acoustic masking of echolocation were derived from a model presented in Appendix 14-B. This model appears well developed using the best information as inputs, and its output seems reasonable. However, as noted previously, there is considerable uncertainty about how echolocation serves SRKWs in prey detection and capture during foraging and thus how foraging efficiency may be affected by noise masking.

The conclusion from the PCoD-Lite model — that individual SRKW's ability to forage in critical habitat when needed will not be adversely affected and that there will not be population-level effects on SRKWs— has a high level of uncertainty because of significant limitations, assumptions and caveats associated with model parameters. Chief among these is that the assumed linkage between vital rates and behavioural disturbance responses and acoustic masking effects, is highly tenuous and uncertain. The following lists some of these limitations, assumptions and uncertainties:

- The PCoD model was parameterized using estimates of SRKW density, predictive models of underwater noise, SRKW-specific behavioural underwater noise thresholds, and an underwater noise masking model (Appendix 14-B). There are considerable assumptions and uncertainties associated with each of these estimates, which could be compounded in the model. For example, dose-response curves to estimate the relationship between received noise levels and behavioural disturbance may be reasonable approximations, but they may be highly context specific and confidence limits may be much wider than predicted. In particular, it is unclear that relationship between dose-response effects and their impact on foraging behaviour is linear.
- Key linkages used in conventional PCoD models are unavailable for SRKWs due to a lack of data. These include the links between prey abundance and foraging success and profitability, between prey intake and body condition, and between body condition and mortality and calving rates. As a result, a 'stripped-down' PCoD-Lite model was used, which bypasses the linkages between nutrition and physiological change or health, and assumes that changes in foraging time result directly in changes in vital rates. This linkage is subject to many uncertainties.
- The SRKW population is very small (~ 80 animals) and changes in survival and fecundity due to demographic stochasticity and other variables not included in the model may have a strong influence on abundance and trends. Population growth projections resulting in the PCoD model thus should be viewed with caution.
- The model assumes a diet of 100% Chinook salmon. Although Chinook salmon is the primary prey of SRKWs in their summer core area, other species can be important at other times of the year and in portions of their range where diet studies have not been conducted.
- There is considerable uncertainty about how echolocation serves SRKWs in prey detection and capture during foraging and thus how foraging efficiency may be affected by noise masking.
- Chinook salmon availability varies widely from year to year, so the impact of potentially reduced foraging time or efficiency due to disturbance or masking on energetics (foraging profitability) and thus mortality and fecundity in the area is likely similarly variable. Reduced foraging may be relatively inconsequential in years of high Chinook abundance, but may be highly significant in poor years.
- The PCoD model was parameterized with estimates that were limited to the Local Study Area and Focused Modelling Area for SRKWs (EIS Figure 14-1), which does not include the Extended Region described in the Marine Shipping Supplement (MSS report Figure 8.2-5). This larger area includes important foraging areas for SRKW in western Juan de Fuca Strait

(currently SRKW critical habitat), and on and near Swiftsure Bank, which has recently been identified as potential additional critical habitat for SRKWs (Ford et al. 2016[6]). Shipping lanes associated with this proposed project overlap this area, and noise related impacts in this area have not been taken into account.

- Inputs into the model do not include existing or future noise effects of small vessel traffic, including whale watching boats.

The conclusion in Section 14.9—that "residual adverse acoustic disturbance to SRKWs from the Project is expected to be not significant"— is given a moderate level of confidence by the Proponent. However, for the reasons stated in comments above, a low confidence level is more appropriate here. It is also concluded in this section that features of SRKW critical habitat, including the acoustic environment and availability of prey, will not be affected by the Project, and as such critical habitat destruction will not take place. However, the Proponent states (Section 14.1.1.1) that destruction of critical habitat has occurred "if part of the critical habitat is degraded, either permanently or temporarily, such that its biophysical features would not be available when needed by SRKWs for foraging, mating, resting, or socializing". The EIS demonstrates that under existing conditions, shipping noise is already causing a reduction in foraging opportunities for SRKWs in their critical habitat, and further reductions are anticipated under future operational conditions if the Project proceeds. This constitutes a temporary loss of function of SRKW critical habitat (diminished foraging due to reduced prey availability through acoustic disturbance and masking). As shipping noise is identified as an activity likely to destroy critical habitat in the *Recovery Strategy for the Northern and Southern Resident Killer Whales (Orcinus ocra) in Canada*, it is recommended that this temporary loss of function be examined with respect to whether or not this would be considered destruction under the SARA. Field studies of both SRKWs (Lusseau et al. 2009) and NRKWs (Williams et al. 2006) show that behavioural disturbance responses resulting from vessels cause a reduction in time spent foraging.

The conclusion in Section 14.9, that effects on Humpback Whales and Steller Sea Lions are expected to be short-term and reversible with no long-term population consequences, and the assigned high confidence level in this conclusion are reasonable for the RAA and LAA areas.

In Sections 14.10 and 14.11 of the EIS, the Proponent appropriately recognizes that it is reasonable to assume that cumulative effects of acoustic disturbance to SRKWs from project construction and operation, in combination with past projects and activities, will remain significant. The Proponent also states that the Project will not contribute a significant cumulative effect of acoustic disturbance on individual SRKW survival and fecundity or on population growth rate *over existing conditions*. This finding should be viewed with caution as it is based on the results of the PCoD-Lite model which, as described above, has multiple compounding uncertainties, assumptions and data gaps in key input parameters that limit its predictive value. Regardless, the Proponent's conclusion of likely and significant residual cumulative effects from the Project over and above existing conditions with a high level of confidence is appropriate.

Similar to the findings in the EIS, in Sections 8.2.8 and 8.2.9 of the MSS report, the Proponent concludes that the effects of marine shipping associated with the Project on SRKWs due to incremental increases in behavioural responses and acoustic masking are not predicted to differ substantially from existing conditions. The MSS report conclusion does not accurately reflect the

[6] Ford, J.K.B., Pilkington, J.F., Reira, A., Otsuki, M., Gisborne, B., Abernethy, R.M., Stredulinsky, E.H., Towers, J.R., and Ellis, G.M. 2016. Information in Support of the Identification of Additional Critical Habitat for Resident Killer Whales (*Orcinus orca*) off the West Coast of Canada. CSAS Working Paper. In revision.

full extent of potential effects of marine shipping associated with the Project on SRKW use of habitat in the Extended Region off the entrance to Juan de Fuca Strait. Recent passive acoustic monitoring at Swiftsure Bank indicates that SRKWs were present on 24% of days over a two-year study period, which is equivalent to an average of 88 days per year (Ford et al. 2016[6]). The area is under consideration for critical habitat designation under SARA, and is used year-round by the SRKW pods K and L, which seldom enter the SRKW RAA during winter and early spring. This area is included in analyses presented in the MSS report, but its importance to SRKWs in terms of annual usage is underestimated as the information provided in Ford et al. (2016) was unavailable to the Proponent. Thus, the magnitude of SRKW exposure to the disturbance and masking effects of Project-related shipping would be greater than described in the EIS and MSS report. Furthermore, the analyses upon which the conclusion is based do not take into account the effects of small vessel traffic in the region nor do projections of future ship transits through Juan de Fuca Strait and approaches include increases in shipping traffic associated with potential expansions of the Ports of Seattle and Tacoma. The Proponent's decision not to re-run the PCoD-Lite model in the MSS report is not of consequence as the high level in uncertainty in this model's results (as described above) would not lead to confident conclusions even if new information on whale occurrence in the Extended Region was included.

In summary, as the Proponent notes, SRKWs are almost certainly experiencing detrimental effects of high underwater noise levels from existing shipping in the region, and that their critical habitat is already degraded. They argue that the Project and additional shipping associated with the Project will only add incrementally to current levels of acoustic disturbance and masking. They conclude that although this will result in a significant cumulative effect, this will not result in increased mortality or decreased fecundity, nor will further degradation of critical habitat constitute destruction as defined in SARA. However, in addition to the various uncertainties and assumptions outlined above, this assumes a linear dose-response relationship between noise and behavioural effects and acoustic masking and the role these effects may play in compromising foraging efficiency. It is likely that this relationship is non-linear, such that additional levels of disturbance may reduce foraging efficiency below a threshold at which it is no longer energetically profitable to forage in the habitat, particularly in years with low prey availability. This could potentially lead to displacement from or abandonment of critical habitat, as well as reduced survival and compromised recovery. It is difficult to estimate the probability of such a scenario being realized, but recognizing the possibility is consistent with an appropriate precautionary assessment of potential impacts. Displacement from habitats due to underwater noise has been documented in a variety of cetaceans (e.g., Anderwald et al. 2013; Haelters et al. 2015), including resident killer whales (Morton and Symonds 2002).

3. Rationale and conclusions related to potential effects of ship strikes, key information gaps and uncertainty

3.1 Background

The risk to SRKWs from ship strikes related to Project activities in the RAA and LAA is described in EIS Section 14.6.2.2. Given the rarity of ship-strike incidents involving large vessels and killer whales, it concludes that "the chance of a Project-related container ship, tug, or support vessel striking a SRKW within PMV jurisdiction and resulting in injury or mortality is qualitatively determined to be very low." The risk to Humpback Whales from ship strikes is described in Section 14.6.3.2. Given that Humpback Whales are not common in the LAA or RAA, it is concluded that "the chance of a Project-related container ship, tug, or support vessel striking a humpback whale within Project scope and resulting in injury or mortality is very low and would not result in population-level effects." Section 14.6.4.2 describes ship strike risk to

Steller Sea Lions and concludes that the chance of a Project-related vessel causing injury or mortality due to collision is very low and thus the risk is negligible.

Risk of ship strike risk to marine mammals in the Extended Region (Juan de Fuca Strait and western approaches) is considered in the MSS report Section 8.2.6.3. Rather than undertaking a quantitative ship strike risk assessment, the Proponent refers to a recent assessment by Stantec (2015) of ship strike risk to cetaceans in the Salish Sea. That assessment was based on tankers travelling at a speed of 12 knots, and it was concluded that the risk to any cetacean was very low. Despite recognizing that container ships associated with the Project would travel at speeds of 20 knots or more and thus be of greater risk of colliding with a marine mammal, the MSS report concluded that the risk to individual SRKW and Steller Sea Lions was still very low. Similar conclusions to those reached in the EIS are made in the MSS report for SRKWs and Steller Sea Lions – the risk is very low. Because Humpback Whales are more vulnerable than these smaller marine mammals to ship strikes, and because humpbacks are often found in Juan de Fuca Strait and in the Extended Region west of the entrance to the Strait, there was recognition that projected future shipping activities could increase the risk of this species being struck. However, the Proponent concludes that such incidents would remain "rare" and would not have a population-level effect.

3.2 Assessment

The conclusion that ships pose a very low risk of causing injury or mortality to SRKWs and Steller Sea Lions through collisions is reasonable. However, the risk to Humpback Whales may be somewhat greater than the Proponent concludes for western Juan de Fuca Strait and the Extended Region to 12 nautical miles west of the entrance to the Strait. A recent assessment of ship strike risk conducted by DFO in Juan de Fuca Strait and off the west coast of Vancouver Island (Nichol et al. 2016[7]) has identified areas with high probabilities of interaction between ships and Humpback Whales. An area of particularly high relative risk is near the entrance to Juan de Fuca Strait and over Swiftsure Bank, where high densities of Humpback Whales occur. Numbers of Humpback Whales using waters in central Juan de Fuca Strait near Victoria also appear to be increasing annually. Because reported vessel strikes due to large, fast moving ships probably under-estimate the true rate of such incidents, it is possible that future increases in shipping may lead to rates of strikes that are more than 'rare'. Although the abundance of Humpback Whales is growing in British Columbia and mortality due to ship strikes and other anthropogenic causes may be minor at the population level, due to high levels of site fidelity by individual Humpback Whales to feeding grounds, shipping associated with the Project could potentially result in local increased lethal encounters in the future (due to both increased whale and ship densities). However, a lack of spatial and temporal distribution data and abundance estimates for Humpback Whales in the central Juan de Fuca Strait area precludes additional modeling to estimate strike risk. Efforts to increase awareness among mariners and other initiatives to mitigate ship strike risk in the Enhancing Cetacean Habitat and Observation (ECHO) program should be encouraged.

[7] Nichol, L.M, Wright, B.W., O'Hara, P. and Ford, J.K.B. 2016. Assessing the risk of lethal ship strikes to humpback (*Megaptera novaeangliae*) and fin (*Balaenoptera physalus*) whales off the west coast of Vancouver Island, Canada. CSAS Working Paper. In revision.

4. Conclusion that the Project would have a negligible effect on the productive potential of juvenile and adult Chinook and Chum Salmon combined, key information gaps and uncertainty

4.1 Background

This section discusses the Proponent's conclusion that the Project would have a negligible effect on the productive potential of Pacific salmon (juveniles and adults of Chinook and Chum combined). Among other reasons, these two species were selected for inclusion in the ecosystem modelling (EIS sections 10.3.3.1 and 10.3.3.2) because they are present in Roberts Bank in high numbers, because some Fraser River Chinook and Chum populations are of conservation concern, and because these two species are important prey species for Southern Resident Killer Whales (SRKWs; Section 13-1 of the EIS).

Chinook salmon (*Oncorhynchus tshawytscha*) has been identified as the preferred prey item of SRKW (COSEWIC 2008, Ford et al. 2010a, 2010b) and recent studies indicate the majority of the Chinook salmon stocks eaten by SRWK in their summer range and critical habitat originate mainly from the Fraser River and Puget Sound (Hanson et al. 2010). These studies also indicate that the frequency of occurrence of Chum salmon (*O. keta*) in SRKW diet increases at the end of the summer and surpasses Chinook salmon frequency of occurrence by early fall (Ford and Ellis 2006, Ford et al. 2010a).

The following subsections summarize the methods used to evaluate the impacts of the Project on these two species of Pacific salmon as stated in the EIS, identify the main sources of uncertainty in the ecosystem model, address some factors that should be closely monitored during the Project construction phase, and discuss relevant conclusions about post-construction (i.e., operation) impacts stated in the Marine Shipping Supplemental Report.

4.1.1 Pacific salmon - Modelling Current Conditions

The Proponent used Ecopath with Ecosim and Ecospace (EwE; Christensen et al. 2005) to assess potential changes in ecosystem productivity resulting from the Project. EwE's representation of an ecosystem are based on "mass balance" derived from fundamental processes such as biomass, production and consumption rates, trophic relationships, and the identification of functional groups to be included in the modelling. The EwE approach and open-source software has been used for ecosystem management throughout the world (Christensen and Walters 2004) and has become a widely-applied ecosystem modelling approach (Colléter 2013). To reduce the complexity of the model, species with similar ecology were aggregated into functional groups. From the 25 focal species selected for assessing Roberts Bank productivity, juvenile and adult groups were separately modeled for Chinook and Chum salmon due to differences in biomass, production and consumption rates, diet, and environmental needs between life stages.

Changes in productivity for the Roberts Bank ecosystem were compared "with" and "without" the Project by incorporating the predicted environmental conditions as determined by changes in five variables: salinity, depth, bottom current, wave height, and hard or soft substrate. These five variables were considered to represent other highly correlated variables. The model predicted changes in productivity using biomass (tonnes) and production (tonnes/year) assuming that the spatial distributions of all functional groups were associated with these five abiotic variables. Changes in productive potential for marine fishes were considered "negligible" for increases or decreases between 0% and 5% (a 5% change was considered to be within the uncertainty range of the model results) and "minor" for increases or decreases between 6% and 30%.The model did not assess potential changes resulting from construction or operation-phase activities.

4.1.2 *Pacific salmon - Modelling Future Conditions*

The ecosystem model measures changes as if these occurred instantaneously, not as a progression over the 5.5-year construction period. Hence, the model output can be seen as two snapshots, one "without" and one "with" the Project (note that the "with" snapshot excluded estimates of potential effects of any offsetting or compensation efforts associated with project implementation). Therefore, changes to marine fish related to project construction were assessed for the horizon year 2021 whereas changes related to project operation were assessed for the horizon year 2030, at which point the ecosystem is expected to reach a new equilibrium.

Overall, the ecosystem model predicted a negligible change of -5% (-14.8t) in the productive potential of Pacific salmon (i.e. juvenile and adult Chinook and Chum salmon combined). More specifically, the ecosystem model predicted a negligible decrease of -5% (-10t) in the productive potential of adult Chinook, a minor increase of +16% (+1t) in juvenile Chinook, a negligible decrease of -5% (-5t) in adult Chum, and a minor increase of +14% (+0.7t) in juvenile Chum. Biotic interactions were identified as likely the key drivers causing increases in juvenile salmon productive potential.

In general, the impacts of the Project on the Roberts Bank ecosystem computed with the model were robust to four types of sensitivity analyses characterized by

a. changes in predator densities;

b. the effects of omitting one abiotic factor at a time;

c. 20% increases or decreases in factor effects; or

d. input parameter uncertainty through Monte Carlo simulations.

In terms of sensitivity to biotic factors, 13 functional groups showed a significant difference in biomass under alternative predator density scenarios. Juvenile Chinook (as much as 8% less than predicted under the key/base model run) and juvenile Chum (as much as 6% less than predicted under the key/base run) were amongst these functional groups. These sensitivity analysis results suggest the predicted increases in juvenile Chum and Chinook salmon derived from the key/base run are likely overestimated.

According to the Marine Shipping Supplemental Report, the assessment of effects of marine shipping is based on the operation phase of the Project as predicted for the year 2030, when the Project is expected to be fully operational. Pacific salmon was chosen as one of four sub-components (other sub-components were intertidal habitat, herring and shellfish) to assess the effects of marine shipping associated with the Project on marine fish and fish habitat. This assessment relied upon existing sources of information to inform both the characterisation of existing conditions and the assessment of incremental changes arising from Project-associated marine vessel activities. Since the objectives of those studies differ from the objectives of this assessment, the effectiveness of those studies to assess the effects of the Project operation is limited. A modelling exercise was used to determine whether noise from Project-associated vessels could be expected to exceed published behavioural thresholds for Pacific salmon. The effect of underwater noise was rated as negligible because noise associated with Project operation (i.e., vessel traffic) is not predicted to exceed injury thresholds for marine fish.

4.2 Assessment

Because the confidence in the EwE's predictions depends on the quality of its input data and modelling settings, the calculations and input data values were reviewed by a third-party panel of experts (Carl Walters, UBC and Dave Preikshot, Madrone Environmental Services). In addition, the Roberts Bank ecosystem model outputs were generally robust to the four types of

sensitivity analyses mentioned in the previous sub-section. These specific types of uncertainties were thoroughly evaluated and documented in Appendix 10-D of the EIS. However, it is important to mention some of the existing limitations, assumptions and uncertainties:

- Mass balance models are deterministic and require many input parameters. In the case of Roberts Bank, data originated mostly from local surveys but some information was extracted from the literature and expert opinion. The main assumptions during the parameterization of the EwE model were that biomass was evenly distributed across habitat, that diet compositions were representative of all species' life stages, that vegetation was mapped accurately, that average EwE parameter values for functional groups were representative of all component species, and that average energetic flows and balances were representative of seasonal conditions.
- Ecosystem modelling did not account for potential injury and direct mortality associated with proposed construction activities, such as the potential entrainment of juveniles during cutter suction dredging, nor did it evaluate the effectiveness of proposed mitigation measures to reduce the potential for construction-related injuries or mortalities.
- The Proponent identified that construction of permanent dykes around terminal basins has a "high" potential effect rating, with the potential to disturb outmigration behavior of juvenile Pacific salmon, including shifts in predator/prey interactions, as a result of changes to habitat. These inferences are derived from the EwE modelling exercise (and did not include an assessment of the potential impact of increased artificial lighting associated with the Project).
- In section 16 of the EIS, inferences are made about the losses of Pacific salmon (in terms of numbers of adult fish) as derived from the ecosystem model. These numbers are derived from estimated change in productive potential associated with the Project and therefore represent only a snapshot comparison of abundance "without" versus "with" the Project. These numbers do not capture cumulative changes in abundance on an annualized basis, either during the construction phase or the 10 years post-construction during which the ecosystem is expected to reach a new equilibrium. Therefore, any comparison with actual (observed) annual average escapements is uninformative.
- While there are several sections that briefly reference potential impacts to migratory behaviour, there is no formal discussion in the EIS about the potential for permanent effects on migratory behaviour of Pacific salmon related to the Project's structures.
- The ecosystem model was not built to measure impacts of the Project on SRKWs or any other marine mammals because important variables such as underwater noise and contaminants were not included. Other models and sources of information were used to assess the effects of the Project on SRKWs and other marine mammals (e.g., the PCoD-Lite model described in Section 14 and Appendix 14-d of the EIS). These impacts, characterized at the individual and population level, are discussed in other sections of this Technical Review.

While the exact value of direct mortality associated with the Project cannot be quantified, the Proponent concludes that direct mortality of juvenile Pacific salmon due to entrainment is likely of minor consequence because there will be little overlap between dredging activities and the temporal and spatial distribution of juvenile salmon in the affected area. Dredging activities are planned for depths up to -30 m below chart datum (CD). To reduce injury and direct mortality during juvenile migration of Chinook and Chum salmon out of the Fraser River, mitigation in the form of a timing window has been incorporated into the construction schedule (Section 4.0 of EIS; no Project-related construction activities that may result in adverse effects to juvenile

Pacific salmon from March 1st to August 15 in depths shallower than -5 m). This mitigation activity should be closely monitored to avoid Project interference with peak fry seaward migrations. However, it is uncertain if this depth limit aligns sufficiently with depths typical for migrating juvenile Pacific salmon. The Proponent states that qualitative and empirical evidence indicates there will be minor decreases in Pacific salmon productivity resulting from direct mortality (more specifically, as related to entrainment), and these will be minimized through mitigation efforts. However, it is unclear what evidence the Proponent is using to support this conclusion. To the contrary, in Section 13 of the EIS, the Proponent cites studies that support the conclusion that direct mortality is expected for juvenile Pacific salmon as a result of dredging (e.g., Nightingale and Simenstad 2001).

Although Section 13 of the EIS concludes that net changes in Pacific salmon productive potential from the Project are expected to be negligible, there is uncertainty regarding the levels of direct mortality during the construction phase. Mitigation activities are seen as a feasible response to this type of uncertainty. In addition to the adherence to timing windows, the Proponent identifies habitat compensation as another important mitigation activity, including refugia openings, construction of artificial reefs and lagoon marshes, as well as placement of sand and gravel to create spawning beaches. Although not all of these habitat-compensation activities are relevant for Pacific salmon, if they are applied, their implementation and maintenance should also be closely monitored.

In an effort to convert the projected changes in Pacific salmon productive potential "with" the Project into numbers of adult fish to infer potential impacts for commercial, recreational, and aboriginal fisheries, the Proponent's approach suggests that only a small fraction of adult fish (0.4% for Chinook and 0.06% for Chum) are expected to be lost compared to average annual escapement data. This comparison is inappropriate because these results represent only a snapshot change in abundance at two different theoretical time points and cannot be compared to annual estimates of abundance. There are also key uncertainties regarding the inferred decreases in abundance. On one hand, inferred decreases in abundance are based on the estimated area lost to the Project footprint, and may be an overestimate. Conversely, the inferred decreases also do not account for any other potential changes in abundance associated with Project construction and post-construction phases (prior to the environment reaching a new equilibrium), and therefore may also be an underestimate. The Proponent's conclusions regarding fisheries impacts predicts losses of adults small enough that they would remain within the range observed through natural variation. However, this conclusion cannot be substantiated because it is based on the EwE snapshot approach and does not take into account injury or direct mortality associated with the construction phase or any permanent effects on migratory behavior as a result of the Project (primarily on juveniles entering the ocean).

The MSS report suggests that potential effects caused by post-construction activities such as vessel wake and underwater noise on marine fish are negligible. However, at present, the nature and extent of behavioural effects of underwater noise on marine fish are not well understood (Popper and Hastings 2009, Slabbekoorn et al. 2010, Halvorsen et al. 2011). Currently, no standard behavioural criteria or thresholds have been established in Canada or elsewhere, mainly due to a lack of scientific data on harmful exposures (Thomsen et al. 2006), especially on a species-by-species basis (Popper et al. 2014). While there are limitations to using a generalised guideline, in the absence of an accepted quantitative threshold, 90 dBht (Nedwell et al. 2007) was used in this assessment as an indicator threshold for potential behavioural effects resulting from underwater noise. The MSS report then concludes that vessel noise will not reach the behavioural avoidance threshold (i.e., 90 dBht) for Pacific salmon and therefore that effects of underwater noise are considered negligible. However, this statement

should be qualified given the uncertainty about the validity of this avoidance threshold for Pacific salmon.

5. Measures proposed by the Proponent to mitigate effects of underwater noise on Southern Resident Killer Whale, key information gaps and uncertainty

5.1 Background

Mitigation of potential effects of underwater noise from project-related activities is described in EIS Section 14.7. It notes that no formal regulations exist regarding underwater noise mitigation and marine mammals, but that guidelines have evolved in Canada to mitigate potential impacts of underwater noise associated with seismic testing and other acute pulsed sound sources. In Section 14.7.1.1, the Proponent proposed a variety of approaches to mitigate noise from terminal construction activities using these guidelines and other recommendations in the scientific literature. The principal approaches include establishing a 'buffer distance' (often called a 'safety zone') around construction activities based on predicted propagation of noise at levels that may cause hearing injury or adverse behavioural effects. Marine mammal observers (MMOs) and hydrophone monitoring would be used to monitor this buffer distance for detections of marine mammals, and appropriate steps would be taken to suspend construction activities until the animal(s) move beyond the buffer distance and remain beyond this distance for 30 min. During periods of darkness or poor visibility, detections will depend on hydrophone monitoring of marine mammal vocalizations. Other proposed mitigation during construction includes shutting-down of noisy equipment when not in use, and various "dampening methods and technologies", but these are not specified.

Section 14.7.1.2 in the EIS considers mitigation of underwater noise associated with the Project. Despite the anticipation of a "measureable residual adverse effect from Project-generated underwater noise", no mitigation measures to reduce noise during operation activities are proposed.

5.2 Assessment

The noise mitigation measures proposed for the Project terminal construction area are standard approaches for such projects and are appropriate. However, if construction activities are undertaken when the buffer distance (or safety zone) is not visible to MMOs due to darkness or fog, hydrophone detection cannot be relied upon with complete certainty as a means to determine if SRKWs are in the area and potentially exposed to high noise levels. Resident killer whales frequently travel in silence, especially when resting, so passive acoustic monitoring would be an ineffective detection method at such times. It is also recommended that MMOs coordinate with existing whale sighting networks to receive advance warning of SRKWs approaching the construction area to facilitate mitigation.

Given that project-related shipping noise is anticipated to cause increased behavioural disturbance and acoustic masking leading to reduced foraging opportunities for SRKWs, and that this could be considered to constitute a loss of function of SRKW critical habitat, it seems that efforts to mitigate any increase in noise in critical habitat are warranted. The SRKW TAG discussed a number of potential mitigation measures that might be considered to maintain underwater noise at or near existing levels despite increasing shipping associated with the Project. For example, a range of quieting technologies and measures are possible (e.g., ship hull and propeller design and maintenance, management of thruster use, improvements to onboard machinery and mounting, and speed restrictions). However, none of these are discussed or proposed in the EIS. The VFPA's current ECHO program, described in the MSS report, includes initiatives to better quantify and potentially mitigate shipping noise. Such efforts

should be encouraged, with an optimal end result being 'no net gain' in ambient shipping noise in SRKW critical habitat as a result of the proposed project.

Conclusions

The information and advice in this Science Response was based on a review of relevant information contained in the *Roberts Bank Terminal 2 Environmental Impact Statement* (EIS) and the *Marine Shipping Supplemental* (MSS) *Report* as it relates to potential effects on marine mammals and marine mammal habitat.

- In general, the data and methods used by the Proponent in their assessment of the potential effects of the proposed project (due to both the construction and ongoing operation) are comprehensive and are the best available.
- Modelling and analyses undertaken in this assessment focused on a reasonable subset of marine mammal species chosen to be representative of each of the marine mammal subcomponents though most of the assessment is focused on Southern Resident Killer Whales (SRKWs) due to the amount of data compiled to inform their *Species at Risk Act* (SARA) listing.
- A state-of-the-art numerical model was used to characterize the potential effects of underwater noise by pile driving and local vessel traffic on the Roberts Bank ecosystem. The assessment used estimates of underwater noise that were based on modeling of sound levels and propagation during construction and operation phases of the project. This model appears well developed using the best information as inputs, and its output seems reasonable. Of particular note is the Proponent's development of killer whale-specific thresholds for behavioural disturbance due to exposure to underwater noise, rather than using generic and somewhat obsolete thresholds commonly applied elsewhere.
- Potential effects of underwater noise on Southern Resident Killer Whales (SRKWs) and their habitat were analyzed using a simplified Population Consequences of Disturbance (PCoD-Lite) model. This model estimates the effects of disturbance on individual survival and fecundity and then projects the results to estimate impacts at the population level. It is important to note that, due to a lack of data, the model involves numerous compounding assumptions and limitations, such that any results have a high level of uncertainty and low confidence, and must be interpreted cautiously.
- The results of the PCoD-Lite model suggest that the Project is not expected to affect survival or fecundity of individuals above levels currently observed, but the Proponent acknowledges that there is considerable uncertainty around these predictions. For example, given that underwater noise associated with recreational and small commercial vessel traffic (e.g. whale watching vessels) was not included in the model, the true effects of existing underwater noise may be under-estimated in the results as presented.
- The Proponent concludes that existing shipping noise is likely affecting the function of SRKW critical habitat through impacts on foraging behaviour due to acoustic disturbance and masking. Additional loss of this function can be anticipated due to increased future shipping associated with the Project unless noise abatement measures are implemented.
- Based on a third-party report of ship strike risk to cetaceans in the Salish Sea (Stantec 2015), the Proponent concludes that there is very low risk of SRKW or Steller Sea Lion injury or mortality due to ship strikes. This conclusion is reasonable; however, the risk to Humpback Whales may be greater than the Proponent anticipates in the extended area outside the VFPA's jurisdiction (i.e. western Juan de Fuca Strait and the Extended Region to

12 nautical miles west of the entrance to the Strait). Recent increases in abundance and high levels of site fidelity by individual Humpback Whales to these feeding grounds could potentially result in local increases in mortality to Humpback Whales from shipping associated with the Project in the future. Quantitative assessment of this risk is currently not possible due to limited available data on humpback whale distribution and abundance in this area.

- The Proponent's conclusion that the Project would have a negligible effect on the productive potential of SRKW prey (i.e. Pacific salmon, namely juvenile and adult Chinook and Chum Salmon) was based on the use of an ecosystem model to predict likely changes in productive potential. Potential effects were assessed by comparing two distinct 'snapshots': conditions "without", and conditions "with", the completed Project in place. These results do not capture cumulative changes in abundance on an annualized basis, either during the construction phase or the 10 years post-construction during which the ecosystem is expected to reach a new equilibrium and therefore, any comparison with actual (observed) average annual salmon escapements is uninformative.
- There is no formal discussion in the EIS about the potential for permanent effects on the migratory behaviour of Pacific salmon (i.e. Chinook and Chum Salmon) related to the Project's structures. Additionally, the Proponent's ecosystem modelling results did not account for injury or direct mortality associated with construction activities or the effectiveness of mitigation measures.
- The noise mitigation measures proposed for the Project's terminal construction area are standard approaches for such projects (marine mammal observers, hydrophone detection systems and passive acoustic monitoring), each with their own advantages and limitations. To facilitate mitigation efforts, it is also recommended that marine mammal observers coordinate with existing whale sighting networks to receive advance warning of SRKWs approaching the construction area.
- The EIS concludes that Project-related shipping noise is anticipated to cause increased behavioural disturbance and acoustic masking leading to reduced foraging opportunities for SRKWs, and that this could be considered to constitute a loss of function of SRKW critical habitat. However, no mitigation of ship noise during operations is proposed in the EIS. As such, development and implementation of mitigation measures that result in 'no net gain' in ambient shipping noise in SRKW critical habitat as a result of the proposed Project is recommended.

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November 28, 2016

Sources of information

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M.D., Donovan, M.O., Pinfield, R., Visser, F. and Walshe, L., 2013. Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. Endangered Species Research. 21(3): 231-240.

Christensen, V., Walters, C.J., and Pauly, D. 2005. Ecopath with Ecosim: a user's guide. Fisheries Centre, University of British Columbia, Vancouver. 154 p.

Christensen, V., and Walters, C.J. 2004. Ecopath and Ecosim: methods, capabilities and limitations. Ecological Modelling 172: 109-139.

Colléter, M., Valls, A., Guitton, J., Morissette, L., Arreguín-Sánchez, F., Christensen, V., Gascuel, D., and Pauly, D. 2013. EcoBase: A repository solution to gather and communicate information from EwE models. Fisheries Centre Research Reports 21(1). The Fisheries Centre, University of British Columbia, Vancouver, B.C.

COSEWIC. 2008. COSEWIC assessment and update status report on the killer whale *Orcinus orca*, Southern Resident population, Northern Resident population, WestCoast Transient population, Offshore population and Northwest Atlantic / Eastern Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 65 pp. (Accessed November 16, 2016).

ESSA Technologies. 2014. Roberts Bank Terminal 2 Project - Environmental Impact Statement. Volume 3: Biophysical Effects Assessments. Appendix 10-D. Roberts Bank Ecosystem Model Sensitivity Analyses. Port Metro Vancouver. (Accessed November 16, 2016)

Ford, J.K.B. and Ellis, G.M. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316:185-199.

Ford, J.K.B., Wright, B.M., Ellis, G.M., and Candy, J.R. 2010a. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/101. iv + 43 pp.

Ford, J.K.B., Ellis, G.M., Olesiuk, P.F., and Balcomb, K.C. 2010b. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? Biology Letters 6:139-142.

Haelters, J., Dulière, V., Vigin, L. and Degraer, S., 2015. Towards a numerical model to simulate the observed displacement of harbour porpoises Phocoena phocoena due to pile driving in Belgian waters. Hydrobiologia. 756(1):105-116.

Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2011. Hydroacoustic Impacts on Fish from Pile Installations. National Cooperative Highway Research Program, Research Results Digest 363:1–24.

Hanson, M.B., Baird, R.W., Ford, J.K.B., Hempelmann-Halos, J., Van Doornik, D.M., Candy, J.R., Emmons, C.K., Schorr, G.S., Gisborne, B., Ayres, K.L., Wasser, S.K., Balcomb, K.C., Balcomb-Bartok, K., Sneva, J.G., and Ford, M.J. 2010. Species and stock identification of prey eaten by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research 11:69–82.

Lusseau, D., Bain, D.E., Williams, R. and Smith, J.C. 2009. Vessel traffic disrupts the foraging behavior of Southern Resident Killer Whales *Orcinus orca*. Endangered Species Research 6:211-221.

Morton, A.B. and Symonds, H.K., 2002. Displacement of Orcinus orca (L.) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science: Journal du Conseil. 59(1):71-80.

Nedwell, J. R., S. J. Parvin, B. Edwards, R. Workman, A. G. Brooker, and J. E. Kynoch. 2007. Measurement and Interpretation of Underwater Noise during Construction and Operation of Offshore Windfarms in U.K. Waters. Subacoustic Report 544R0738. Prepared for COWRIE Ltd.

Nightingale, B.J., and Simenstad, C.A. 2001. Dredging Activities: Marine Issues. Washington State Transportation Center, University of Washington, Seattle, WA.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. National Academy Press, Washington, DC.

Popper, A. N., and M. C. Hastings. 2009. The Effects of Anthropogenic Sources of Sound on Fishes. Journal of Fish Biology 75:455–489.

Popper, A. N., A. D. Hawkins, R. R. Fay, D. A. Mann, S. Bartol, T. J. Carlson, S. Coombs, W. T. Ellison, R. L. Gentry, M. B. Halvorsen, S. Løkkeborg, P. H. Rogers, B. L. Southall, D. G. Zeddies, and W. N. Tavolga. 2014. ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Volume ASA S3/SC1.4 TR-2014. SpringerBriefs in Oceanography.

Port Metro Vancouver. 2015a. Roberts Bank Terminal 2 Project - Environmental Impact Statement. (Accessed November 16, 2016)

Port Metro Vancouver. 2015b. Roberts Bank Terminal 2 Project - Marine Shipping Addendum to the Environmental Impact Statement. Section 8.2. Marine Mammals Effects Assessment. (Accessed November 16, 2016)

Slabbekoorn, H., N. Bouton, I. van Opzeeland, A. Coers, C. ten Cate, and A. N. Popper. 2010. A Noisy Spring: The Impact of Globally Rising Underwater Sound Levels on Fish. Trends in Ecology and Evolution 25:419–27.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E. and Richardson, W.J., 2007. Special Issue: Marine mammal noise exposure criteria. Aquatic Mammals, 33(4).

SMRU Canada Ltd. 2014a. Roberts Bank Terminal 2 Project - Environmental Impact Statement. Appendix 14-B. Southern Resident Killer Whale Underwater Noise Exposure and Acoustic Technical Report. (Accessed November 16, 2016)

SMRU Canada Ltd. 2014b. Roberts Bank Terminal 2 Project - Environmental Impact Statement. Appendix 14-C. Southern Resident Killer Whale Population Consequence of Disturbance Model. (Accessed November 16, 2016)

Stantec. 2015. Quantitative Assessment of Increased Potential for Marine Mammal-Vessel Interactions from the Trans Mountain Expansion Project. (Accessed November 16, 2016)

Thomsen, F., K. Lüdemann, R. Kafemann, and W. Piper. 2006. Effects of Offshore Wind Farm Noise on Marine Mammals and Fish. Technical Report, Prepared by Biola, Hamburg Germany, for COWRIE.

Williams, R., Lusseau, D. and Hammond, P.S. 2006. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation, 133:301-311.

This Report is Available from the

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ISSN 1919-3769
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Correct Citation for this Publication:

DFO. 2017. Technical Review of Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/001.

Aussi disponible en français :

MPO. 2017. Examen technique de l'énoncé des incidences environnementales sur le Terminal 2 à Roberts Bank et rapport complémentaire sur la navigation maritime : Effets sur les mammifères marins. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2017/001.